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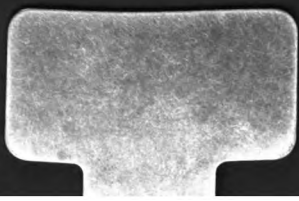
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MANUAL
FOR
GAS ENGINEERING
STUDENTS

D. LEE

1807.f.21.



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BY D. LEE.

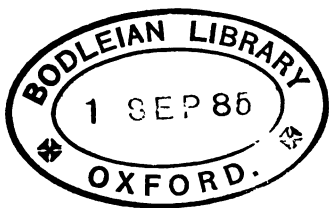


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PREFACE.

THE author of this little work has frequently thought that it would be a great boon to students preparing themselves for the gas engineering profession, if they could with greater facility acquire a knowledge of the manner in which some of the calculations daily practised by engineers are worked out.

As there appears to be a long-felt want in this direction, the following examples are respectfully submitted, with a hope that they may possibly be the means, or perhaps at least be of some service, towards supplying the deficiency.

D. LEE.

NOTTINGHAM, 1885.

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MANUAL
FOR
GAS ENGINEERING
STUDENTS.

GAS MADE.

The quantity of gas made will be the number of cubic feet produced, passed through and registered by the station meter, and corrected for temperature and pressure, the thermometer to be taken at 60° Fahrenheit, and the barometer at 30 inches.

Example for Temperature only.

Multiply the quantity of gas produced by 508, and for a divisor add any number of degrees above 60° to

Gas expands $\frac{1}{50}$ of its volume for every degree of temperature above 32° Fahr.

508, if below 60° *deduct* any number of degrees from 508.

Gas produced . . . 1,291,000 cubic feet.
 Temperature . . . 64° Fahrenheit.

$$508 + 4 = 512$$

$$\frac{1,291,000 \times 508}{512} = \frac{655,828,000}{512} = 1,280,000 \text{ cub. ft.}$$

Example for Temperature and Pressure.

Calculated from the formulæ $\frac{17 \cdot 64 (h - a)}{460 + t}$

Gas produced . . . 1,291,000 cubic feet.
 Temperature . . . 64° Fahrenheit.
 Barometer . . . 30 inches.
 Tab. num. for ther. and bar. . 990

$$1,291,000 \times \cdot 990 = 1,278,000 \text{ cubic feet.}$$

<i>Example.</i> Bar. 30·00 ·596 — 29·404 29·404 × 17·64 — 524 = ·990 460 + 64 = 524	Table for Correction of Gas at different Temperatures and different Atmospheric Pressures.		Tension of Aqueous Vapour in inches of Mercury to be deducted from any Barometer.	
	Bar.	Tab. num.	Fahr.	Ins.
	30·0	1·050	40°	·248
	"	1·025	50	·361
	"	1·000	60	·518
	"	·990	64	·596
	—	—	—	—
	—	—	—	—
	"	·946	80	1·023

GAS MADE PER MOUTHPIECE.

The number of cubic feet produced, passed through and registered by the station meter, corrected for temperature and pressure, and the result divided by the total number of retort mouthpieces in action, will be the gas made per mouthpiece.

Example.

Gas produced . . . 8,650,000 cubic feet.
Mouthpieces in action . . . 1,730

$$\frac{8,650,000}{1730} = 5000 \text{ cubic feet per mouthpiece.}$$

GAS MADE PER TON.

The total number of cubic feet produced, registered by the station meter, corrected for temperature and pressure, with the result divided by the total number of tons of coal carbonized, will be the gas made per ton.

Example.

Gas produced . . . 8,650,000 cubic feet.
Coal carbonized . . . 865 tons.

$$\frac{8,650,000}{865} = 10,000 \text{ cubic feet per ton.}$$

GAS CONSUMED.

The gas consumed will be the difference between the stock in the gasholders, taken in the evening at opening time, and in the morning at shutting-off time; this difference (if any) should be added to or deducted from (as the case may be) the make of gas as registered by the station meter and corrected for temperature and pressure. If the stock in the gasholders *decreases*, the difference between the two stocks should be *added* to the gas made per meter, but if on the contrary it *increases*, the difference should be *deducted* therefrom.

Example for Decrease in Stock.

Stock, 6 o'clock P.M.	2,400,000	cubic feet.
" 6 " A.M.	500,000	"
Decrease in stock .	1,900,000	"
Made per meter .	2,000,000	"
Total consumption	3,900,000	"

Example for Increase in Stock.

Stock, 6 o'clock P.M. .	500,000	cubic feet.
" 6 " A.M. .	1,400,000	"
Increase in stock .	900,000	"
Made per meter .	1,900,000	"
Total consumption	1,000,000	"

GAS UNACCOUNTED FOR.

The quantity of gas unaccounted for will be the difference between the gas produced and registered by the station meter, and the gas registered by the consumers' meters, including also the gas used in the works; the stock in the gasholders to be taken into account and allowed for at the beginning and at the end of each quarter, in the manner previously described on p. 12.

Example.

Gas registered by station meter, with additions or deductions in stock, as the case may be . . .	}	378,000,000 cubic feet.

Gas registered by the con- sumers' meters and used in works	}	348,000,000 „
		<hr/>
		30,000,000 „
		<hr/>

$$\frac{30,000,000 \times 100}{378,000,000} = 7.93 \text{ per cent. unaccounted for.}$$

COAL CARBONIZED.

The number of charges, or in other words the number of retort mouthpieces in action, multiplied by the weight of each charge in hundredweights, and the result divided by 20, will give the total quantity of coal carbonized in tons.

Example.

Number of charges 2668
 Weight of each charge $2\frac{1}{2}$ cwts.

$$\frac{2668 \times 2\frac{1}{2} \text{ cwt.}}{20} = \begin{array}{r} \text{Tons} \\ 333 \end{array} \begin{array}{r} \text{Cwts.} \\ 10 \end{array} \begin{array}{r} \text{Qrs.} \\ 0 \end{array}$$

Cubic feet $\div 44$ = tons of Staffordshire, Derbyshire, or Yorkshire coal (average).

TAR MADE PER TON.

The total quantity of tar made in gallons, divided by the total number of tons of coal carbonized, will determine the number of gallons of tar made per ton.

Example.

Tar made, 9110 gallons. | Coal carbonized, 911 tons.

$$\frac{9110}{911} = 10 \text{ gallons per ton.}$$

Gallons of tar $\div 200$ = tons avoirdupois.

Cubic feet of tar $\div 32$ = " "

Specific gravity ranges from 1120 to 1150 (water 1000).

LIQUOR MADE PER TON.

The total quantity of ammoniacal liquor made in gallons, divided by the total number of tons of coal carbonized, will determine the number of gallons of liquor made per ton.

Example.

Liquor made	.	.	22,775 gallons.
Coal carbonized	.	.	911 tons.

$$\frac{22,775}{911} = 25 \text{ gallons per ton.}$$

Cubic feet $\times 6.24 =$ gallons.

TESTS FOR AMMONIACAL LIQUOR.

TWADDLE'S HYDROMETER TEST.

Twaddle's No. 1 hydrometer is used for ascertaining the strength of ammoniacal liquor, the tube being graduated into degrees, commencing at the top with zero, which indicates pure water at 60° Fahrenheit, ranging downwards towards the bulb to 24° Twaddle.

The specific gravity is estimated by the depth which the instrument sinks in it, for the less the specific gravity the further will it sink, or in other words the heavier fluids will buoy up the instrument more than such that are lighter.

There is a smaller bulb attached to the instrument

below, which contains a little mercury, but this is merely for the purpose of equa-poising it so as to make it remain upright in the liquor under trial.

The number of degrees read off and multiplied by 2 will give the quantity of sulphuric acid, of specific gravity 1845, required to neutralize 1 gallon.

Example.

$3^{\circ} \times 2 =$	6 oz. of sulphuric acid or	6 oz. liquor.
$4 \times 2 =$	8 " "	8 "
$5 \times 2 =$	10 " "	10 "

To ascertain the actual amount of ammonia present in each gallon of liquor, it will only be necessary to read off the number of degrees indicated on the hydrometer tube (Ther. 60°) multiply by 2, and divide the result by 3, the quotient will give the quantity of ammonia in ounces.

Example.

$$\frac{3^{\circ} \times 2}{3} = 2 \text{ oz. of ammonia per gallon.}$$

$$\frac{4^{\circ} \times 2}{3} = 2.66 \text{ oz. " " "}$$

$$\frac{5^{\circ} \times 2}{3} = 3.33 \text{ oz. " " "}$$

Below 3° or 6 oz. acid will not pay for working.

To convert degrees Twaddle into real gravity multiply the number of degrees by 5 and add 1.000 to the product, thus $5 \times 5 = 25 + 1.000 = 1.025$; if the weight in pounds per gallon of the liquor be required, divide real gravity by 100, thus, $1.025 \div 100 = 10.25$ lb., or if the number of gallons in a ton of the liquor be required, the weight per gallon in pounds being known, then $10.25 : 1 :: 2240 : 219.5$, the number of gallons in 1 ton, and again if 219.5 be multiplied by $4\frac{1}{2}$, the result will be 1000 gallons of ammoniacal liquor to every $4\frac{1}{2}$ tons (nearly).

THE ACID TEST.

Hydrometers are at best but a mere approximation to the truth, the following being a more accurate test.

Take 1 lb. of oil of vitriol (sp. gr. 1845) and add distilled water till the mixture measures 1 gallon, this forms the test acid. Fill the alkalimeter to zero with the ammoniacal liquor to be tested, and pour it into a clean earthenware dish, then wash out the alkalimeter, and fill to the same zero line with test acid; add the acid to the ammoniacal liquor, carefully stirring the while with a glass rod, till a blue litmus

paper dipped in the mixture becomes slightly reddened, read off the quantity of test acid poured into the dish, which will be the number of ounces of oil of vitriol taken to saturate 1 gallon.

STRENGTH OF LIQUOR LOADED IN BOATS OR TANKS.

The average strength in degrees Twaddle of ammoniacal liquor loaded into boats and despatched during the quarter may be ascertained in the following manner, viz. :—

Example.

QUARTER ENDING SEPTEMBER 30TH, 1884.

Boats.	Gallons.	Average deg. Twad.	Deg. Twad.	Deg. Twad.
2	9,000	× 4°·25	= 38,250	4° to 4½°
1	4,500	× 4°·75	= 21,375	4½ to 5
—	—		—	
—	—		—	
—	—		—	
—	—		—	
—	—		—	
—	—		—	
64	288,000		1,631,250	
$\frac{1,631,250}{288,000} = 5°·66 \text{ (average) degrees Twaddle.}$				

COKE AND BREEZE MADE PER TON.

The quantity of coke made per ton of coal carbonized varies considerably with the different kinds of coal used, but an average of about $13\frac{1}{2}$ cwts. per ton may fairly be assumed as being approximately correct.

When coke is stored in large heaps it will be necessary to measure it to ascertain the contents in cubic feet, this having been done, deduct $\frac{1}{4}$, or 25 per cent., for breeze; the residue divided by—

1·28	cubic feet	will give the contents in bushels.
3·85	"	" " " " sacks.
46·22	"	" " " " chaldrons.

This is assuming the bushel to contain 2218·19 cubic inches, 3 bushels to be 1 sack, and 12 sacks or 36 bushels to be 1 chaldron.

The breeze made per ton will be the 25 per cent. as above deducted from the coke, subject to a further reduction of 50 per cent., or one-half, as an allowance for dust.

COST PER 1000 FOR CARBONIZING.

The cost per thousand for carbonizing may be ascertained by reducing the total amount of stokers' wages to pence, and dividing the sum by the total number of cubic feet of gas produced, registered by the station meter and corrected for temperature and pressure.

Example.

Gas produced . . . 8,016,000 cubic feet.

Stokers' wages . . . 100*l.* 4*s.* 2*d.*

$$\frac{100*l.* 4*s.* 2*d.* \times 20 \times 12}{8,016,000} = \frac{\overset{\text{Pence.}}{24,050}}{8,016,000} = 3.00*d.* \text{ per 1000 cubic feet.}$$

COST PER 1000 FOR PURIFICATION.

The total amount of wages paid for charging, emptying, and re-charging the purifiers, reduced to pence, and the sum divided by the total number of cubic feet of gas produced, will determine the cost per 1000 for purification.

Example.

Gas purified . . . 8,016,000 cubic feet.

Wages . . . 16*l.* 15*s.* 0*d.*

$$\frac{16*l.* 15*s.* 0*d.* \times 20 \times 12}{8,016,000} = \frac{\overset{\text{Pence.}}{4020}}{8,016,000} = \frac{1}{2}*d.* \text{ per 1000 cubic feet.}$$

PHOTOMETRICAL TABLES.

To construct a table that will show the number of grains of sperm consumed in 10 minutes in proportion to the time occupied in the consumption of 40 grains.

Reduce the time occupied in burning 40 grains to seconds, thus— $10 \overset{\text{m.}}{23} \times 60 = 623$, and also reduce the 10 minutes to seconds, thus— $10 \times 60 = 600$, then $623 : 40 :: 600 : 38.52$.

Example.

	Time consuming 40 grains.	Sperm consumed in 10 minutes.
8.8		
8.6		
9.0		
—		
—		
—		
—		
10) 92.9	10.00	40.00
—	—	—
9.29	—	—
38.52	—	—
—	10.23	38.52
20) 357.8	10.24	38.46
—	10.25	38.40
17.89 candles.		

To use the tables, assuming everything to be properly adjusted, put the 40-grain weight in the scale and start the minute clock, note the time taken to consume the 40 grains and refer to the tables for the numbers standing opposite the time, which will be the multiplier required ($10.23 = 38.52$).

STATEMENT OF RESIDUAL PRODUCTS.
For the Quarter ending September 30th, 1884.

Description of Residual.	In Store, June 30, 1884. Estimated.	Made during the Quarter. Estimated.	Used in manufacture during the Quarter. Estimated.	Sold during the Quarter.	In Store, Sept. 30, 1884. Estimated.
Common coke, (chaldrons of 36 bushels)	600	12,000	3,000	8,000	1,600
Best coke (" ")	100	1,000	—	900	200
Breeze (" ")	200	800	600	100	300
Tar (gallons)	17,000	130,000	—	120,000	27,000
Ammoniacal liquor (butts of 108 gallons)	500	1,500	—	1,800	200

Example.

$$(600 + 12,000) - (3000 + 8000) = 1600.$$

THE JET PHOTOMETER.

The action of the jet photometer is based on the assumption that, the richer the quality of the gas the higher will be the flame, therefore the flame of a rich gas that contains more carbon than that of a poorer one will have to ascend higher in the atmosphere to procure the additional supply of oxygen necessary for its perfect combustion.

The poorer gas having less carbon will not require so much oxygen, and of course will have a shorter flame. The flame issues from the jet under a constant pressure and from an orifice of fixed dimensions.

Example.

Pressure.

·63	of an inch	=	14	candles,	7-inch	flame.
·575	"	=	16	"	7	" "
·520	"	=	18	"	7	" "
·465	"	=	20	"	7	" "



